Measurement and debugging of ultrasonic switching circuit

1. Task name

This project is the measurement and debugging of ultrasonic switching circuit. Ultrasound refers to sound waves with a vibration frequency greater than 20 kHz that cannot be heard and felt by humans in the natural environment. Ultrasound is not only widely used in diagnostics, therapy, engineering, biology and other fields, but is also widely used in daily life. Ultrasound has many characteristics, such as strong directionality and relatively concentrated energy when propagating; ultrasonic waves can propagate in various media and can propagate far enough distances; the interaction between ultrasound and sound transmission media is moderate, and it is easy to carry Information about the status of the sound transmission medium. 2. Task description 1. Composition of

ultrasonic switch circuit

Ultrasonic switch circuit is mainly composed of

ultrasonic transmitting circuit and ultrasonic receiving circuit. (1) Ultrasonic transmitter circuit Figure 2.2.1 shows the

ultrasonic transmitter circuit,

which is mainly composed of 5 5 5 time base oscillation circuit and drive transducer circuit group. It is the PCB of the ultrasonic transmitter circuit.

picture.

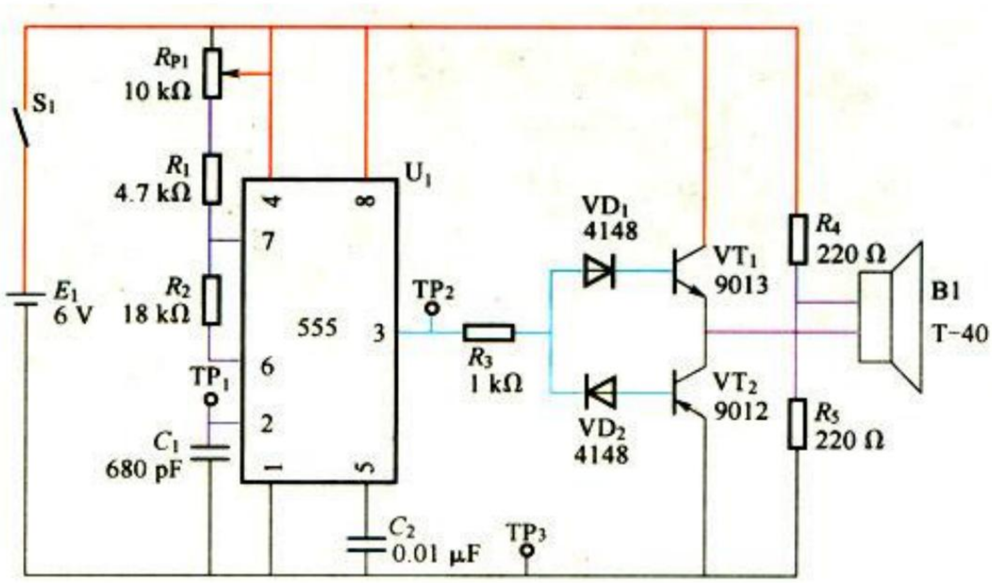


图 2.2.1 超声波发射电路

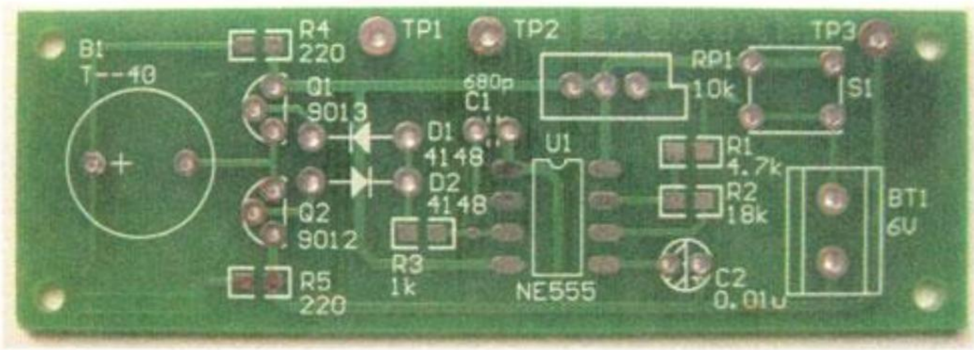


图 2.2.2 超声波发射电路的 PCB 图

(2) Ultrasonic receiving circuit

Figure 2.2.3 shows the ultrasonic receiving circuit, which mainly consists of an amplifier circuit, a detection circuit, a voltage comparison circuit and a circuit. Figure 2.2.4 is the PCB diagram of the ultrasonic receiving circuit.

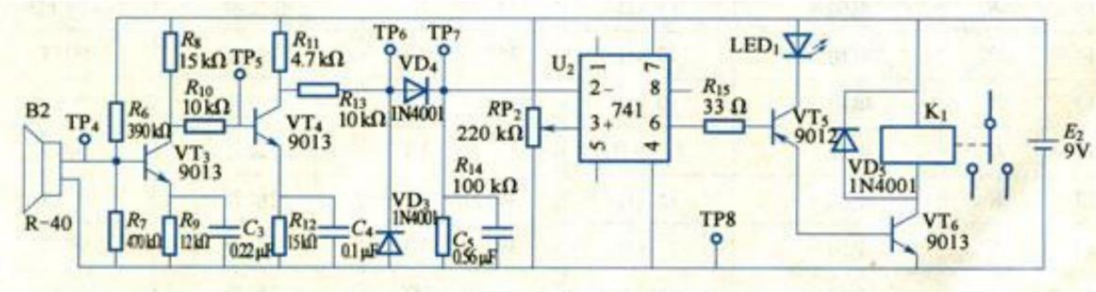


图 2.2.3 超声波接收电路

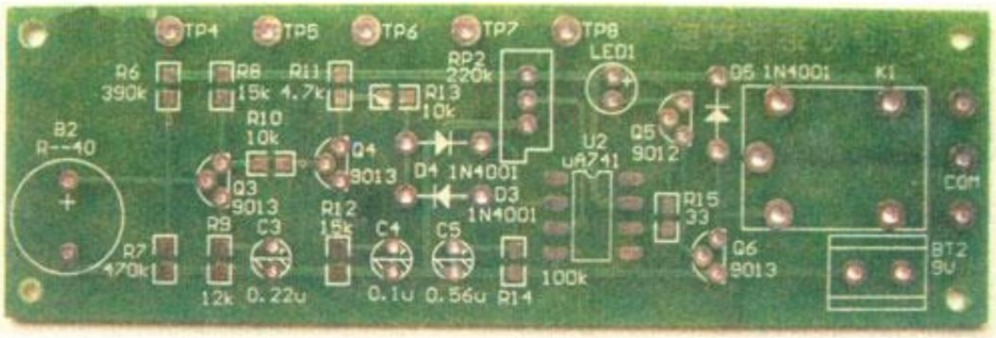


图 2.2.4 超声波接收电路的 PCB 图

(3) Components list of ultrasonic switch circuit

The component list of ultrasonic switch circuit is shown in

Table 2.2.1. Table 2.2.1 Ultrasonic switch circuit component list

序号	标称	名称	规格	序号	标称	名称	规格
1	C_1	电解电容	680 pF	22	VD_2	二极管	4148
2	C_2	电容	0.01 μF	23	VD_3	二极管	1N4001
3	C_3	电容	0.22 μF	24	VD_4	二极管	1N4001
4	C_4	电容	0.1 μF	25	VD_5	二极管	1N4001
5	C_5	电解电容	0.56 μF	26	U_1	集成块 *	NE555
6	R_1	电阻 *	4.7 kΩ	27	U_2	集成块 *	μA741
7	R_2	电阻 *	18 kΩ	28	BT_1	扣线插座	
8	R_3	电阻 *	1 kΩ	29	BT_2	扣线插座	
9	R_4	电阻 *	220 Ω	30	LED_1	发光二极管	
10	R_5	电阻 *	220 Ω	31	K_1	继电器	
11	R_6	电阻 *	390 kΩ	32	S_1	按键开关	
12	R_7	电阻 *	470 kΩ	33	R_{P1}	电位器	10 kΩ
13	R_8	电阻 *	15 kΩ	34	R_{P2}	电位器	220 kΩ
14	R_9	电阻 *	12 kΩ	35	VT_1	三极管	9013
15	R_{10}	电阻 *	10 kΩ	36	VT_2	三极管	9012
16	R_{11}	电阻 *	4.7 kΩ	37	VT_3	三极管	9013
17	R_{12}	电阻 *	15 kΩ	38	VT_4	三极管	9013
18	R_{13}	电阻 *	10 kΩ	39	VT_5	三极管	9012
19	R_{14}	电阻 *	100 kΩ	40	VT_6	三极管	9013
20	R_{15}	电阻 *	33 Ω	41	TP_1	测试杆	
21	VD_1	二极管	4148	42	TP_2	测试杆	

序号	标称	名称	规格	序号	标称	名称	规格
43	TP_3	测试杆		47	TP_7	测试杆	
44	TP_4	测试杆		48	TP_8	测试杆	
45	TP_5	测试杆		49	B_1	超声波发射头	T－40
46	TP_6	测试杆		50	B_2	超声波接收头	R－40

注：表格中名称旁边标有＊号的元器件为贴片元器件

The function of the ultrasonic switch circuit is: when we hold the ultrasonic transmitting circuit and align it with its receiving circuit and press the transmitting switch, the ultrasonic The sound wave transmitting circuit will emit ultrasonic waves. When the ultrasonic wave receiving circuit receives the ultrasonic signal, it will amplify, detect and compare the voltage, and then control the relay to output a switching signal. We can use its output switching signal to control the switching of other electrical equipment. . 2. Description of ultrasonic switch circuit function 3. The test diagram 2.2.5 of the test point waveform is a physical diagram of the ultrasonic transmitting circuit.

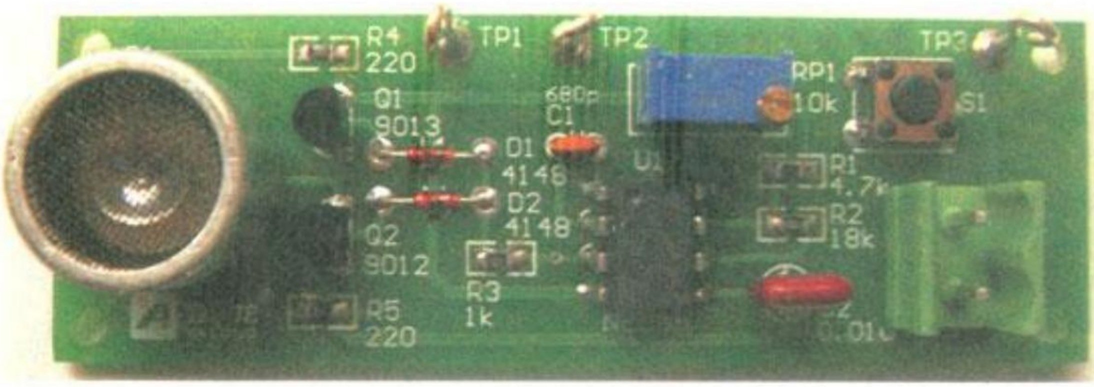


图 2.2.5 超声波发射电路实物图

The test points of the ultrasonic transmitting circuit are TP1 and TP2. Fill in the test waveforms in Table 2.2.2 respectively (fill in the waveform of TP1) And in Table 2.2.3 (fill in the waveform of TP2), where TP3 is the negative pole of the transmitter circuit power supply.

表 2.2.2 TP_1 的波形

TP_1 波形	周期/频率	幅 度
	示波器测量： Time/div = T = f = 频率计测量： T = f =	示波器测量： V/div = U_{P-P} = U_P = U =

表 2.2.3 TP_3 的波形

TP_3波形	周期/频率	幅　度
	示波器测量： Time/div = T = f = 频率计测量： T = f =	示波器测量： V/div = U_{P-P} = U_P = U =

After installing the circuit, the test points of the ultrasonic receiving circuit are TP4, TP5, TP6 and TP7, as shown in Figure 2.2.6. Fill in the test waveforms into Table 2.2.4 (fill in the waveform of TP4), Table 2.2.5 (fill in the waveform of TP5), Table 2.2.6 (fill in the waveform of TP6) and Table 2.2.7 (fill in the waveform of TP7) respectively. waveform), TP8 is the negative pole of the ultrasonic receiving circuit power supply.

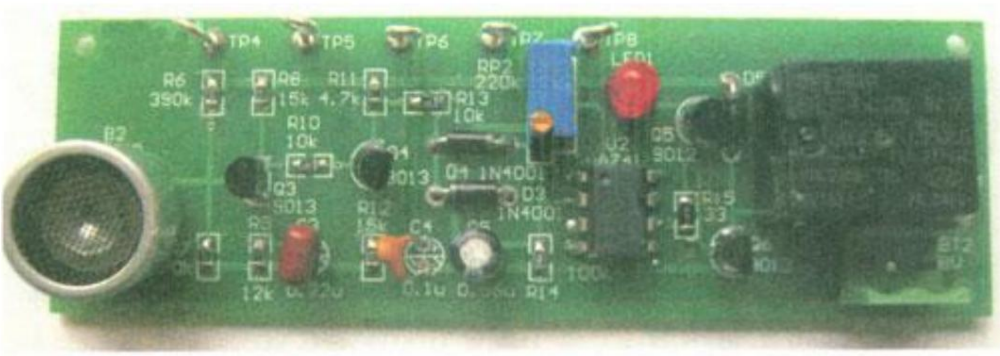


图 2.2.6 超声波接收电路实物电路图

表 2.2.4 TP_4 的波形

TP_4波形	周期/频率	幅　度
	示波器测量： Time/div = T = f = 频率计测量： T = f =	示波器测量： V/div = U_{P-P} = U_P = U =

表 2.2.5 TP_5 的波形

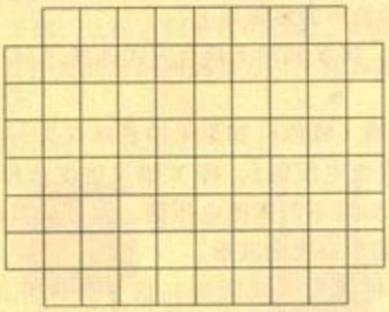
TP_5 波形	周期/频率	幅 度
	示波器测量： Time/div = T = f = 频率计测量： T = f =	示波器测量： V/div = U_{P-P} = U_P = U =

表 2.2.6 TP_6 的波形

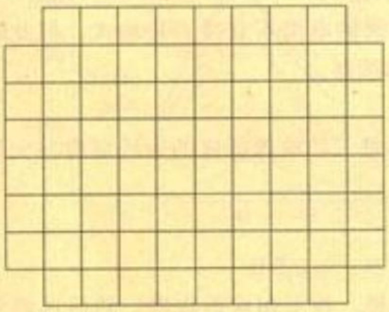
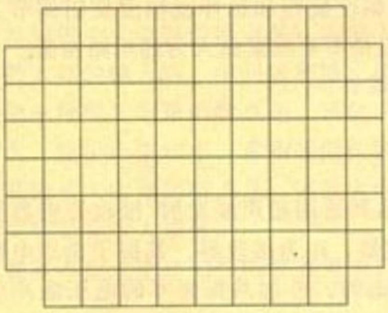
TP_6 波形	周期/频率	幅 度
	示波器测量： Time/div = T = f = 频率计测量： T = f =	示波器测量： V/div = U_{P-P} = U_P = U =

表 2.2.7 TP_7 的波形

TP_7 波形	周期/频率	幅 度
	示波器测量： Time/div = T = f = 频率计测量： T = f =	示波器测量： V/div = U_{P-P} = U_P = U =

4ÿ Use of instruments and equipment (1)

Steps for using an oscilloscope

An oscilloscope can be used to observe the waveform curves of various electrical signal amplitudes changing with time, so that the oscilloscope can measure voltage, Time, frequency, phase difference and amplitude modulation, etc. The steps to observe a waveform of an electrical signal with an oscilloscope are as follows:

ÿSelect the Y-axis coupling mode. According to the frequency of the signal being measured, select the Y-axis input coupling mode as "AC one ground one "DC" switch is set to AC or DC. ÿSelect the Y-axis

sensitivity. The oscilloscope determines the approximate peak-to-peak value of the signal being measured (if an attenuation probe is used, it should be divided by the attenuation multiple; when selecting the DC block in the coupling mode, the superimposed DC voltage value), set the Y-axis sensitivity selection V/div switch (or Y-axis attenuation switch) to the appropriate level. If you do not need to read the measured voltage value in actual use, you can appropriately adjust the Y-axis sensitivity fine-tuning (or Y-axis attenuation switch). Gain) knob to display the waveform with the required height on the screen.

ÿSelect the trigger (or synchronization) signal source and polarity. Usually the trigger (or synchronization) signal polarity switch is placed in the "+" or "one" position. ÿSelect

the scanning speed. Set the X-axis

scanning speed Time/div (or scanning range) switch to the appropriate level based on the approximate value of the period (or frequency) of the signal being measured. In actual

use, if there is no need to read the measurement time value, the scanning speed can be adjusted appropriately.

Time/diV trim (or sweep trim) knob to display the waveform of the required number of cycles for the test on the screen. If what needs to be observed is the edge part of the signal, the sweep

speed Time/div switch should be set to the fastest sweep speed.

ÿInput the signal to be measured. The measured signal is attenuated by the probe (or directly input by the coaxial cable without attenuation, but the output at this time

(The input impedance decreases and the input capacitance increases), input the oscilloscope through the Y-axis input

terminal. (2) Steps for using the signal generator: ÿ

Connect the power cord to the 220 V \ 50 Hz AC power supply. It should be noted that the ground end of the three-core power socket should be properly connected to the earth to

avoid interference. ÿ Before starting

up, each output knob on the panel should be turned to the minimum. ÿ In order to obtain

sufficient frequency stability, preheating is required. ÿ Frequency adjustment: The

frequency band buttons on the panel are used for frequency band selection. Press the corresponding button and then adjust the coarse adjustment.

and fine adjustment to the required frequency. At this time, the "internal and external measurement" key is set to the internal measurement position, and the frequency of the output signal

is displayed

by the 6-digit digital tube. ÿWaveform conversion: According to the required waveform type, press the corresponding waveform key. The waveform selection keys from left to right are

rectangular wave, sharp pulse, and sine wave.

ÿAmplitude adjustment: The amplitude of sine wave and pulse wave are adjusted by the sine wave amplitude knob and pulse wave amplitude knob respectively. This machine

Fully consider the accidental short circuit of the output and add certain safety measures, but do not conduct frequent artificial short circuit experiments.

ÿRectangular wave pulse width adjustment: Adjust through the rectangular pulse width adjustment knob. 3.

Relevant knowledge 1. Related

component knowledge Figure 2.2.7

shows the actual ultrasonic sensor, T/R-40-×× series general-purpose ultrasonic transmitting/receiving sensor, which is a sensor that uses the piezoelectric effect and is usually

called a transducer. T is the transmitter, R is the receiver, its vibrator is made of piezoelectric ceramics, and the addition of a resonant horn can improve the action sensitivity. When it is in the

transmitting state, the applied voltage of the resonant frequency can generate ultrasonic waves and convert electrical energy into mechanical energy; when When in the receiving state, it can

sensitively detect ultrasonic waves at the resonant frequency and convert mechanical energy into electrical energy. Figure 2.2.8 shows the internal structure of an ultrasonic sensor. This type of

sensor is most suitable for anti-theft alarm and remote control use. When an oscillation pulse of 40 kHz is applied to the two electrodes of the ultrasonic sensor, a vibration effect occurs in

the resonant plate of the transmitter, resulting in a 40 kHz ultrasonic oscillation mechanical wave that radiates to the outside. When the receiving sensor receives an ultrasonic oscillation wave of 40

kHz, the resonant plate (chip-shaped vibrator) in the receiver resonates with the external 40 kHz ultrasonic wave, and converts the ultrasonic wave into an electrical signal to control the operation

of the electronic circuit, thereby achieving the purpose of remote control. If the modulated signal of the transmitter contains a coding function, the amplification circuit of the receiving circuit must

have a corresponding decoder to work. The frequency characteristic curve of the ultrasonic sensor is shown in Figure 2.2.9.

图 2.2.7 超声波传感器实物图

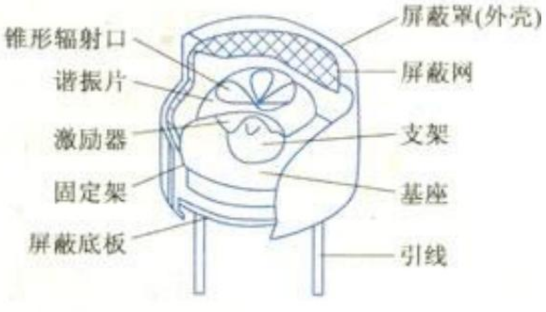


图 2.2.8 超声波传感器内部结构图

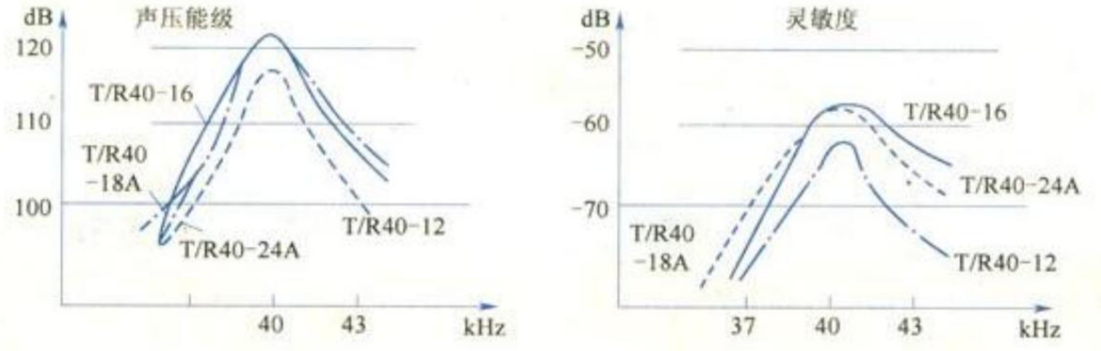


图 2.2.9 超声波传感器频率特性曲线图

2. Amplification circuit knowledge

ÿ Electronic circuits used to increase the amplitude or power of electrical signals are called amplifier circuits. ÿThe

basic forms of amplifier circuits are: common emitter amplifier circuit, common base amplifier circuit and common collector amplifier circuit c. When forming a multi-stage amplifier, these amplifier circuits often need to be used in combination with each other. The three amplification circuits of triode are shown in Figure 2.2.10.

The characteristics of the common emitter amplifier circuit are: the voltage, current, and power amplification factors of this amplifier circuit are large, so the application In the input stage, intermediate stage and output stage of multi-stage amplifier.

The characteristics of the common collector amplifier circuit are: this amplifier circuit only has current amplification function and no voltage amplification function. Its input resistance is large and the output resistance is small. It is often used in impedance matching and buffer circuits.

The characteristics of the common base amplifier circuit are: This amplifier circuit mainly has good frequency characteristics, so it is mostly used for high-frequency amplification, high-frequency oscillation and wide-bandwidth amplifiers.

The performance characteristics of the three basic amplifier circuits are shown in Table 2.2.8.

ÿThe performance indicators of the amplifier circuit include amplification factor, input resistance, output resistance, pass frequency band, maximum undistorted output voltage, maximum output power Pom, efficiency ÿ and nonlinear distortion.

Magnification: Magnification is a measure of the amplification capability of an amplifier circuit. It is defined as the ratio of the output variable value to the input variable value, sometimes also called gain. Although the amplifier circuit can achieve power amplification, in many situations, people often only care about the amplification factor of a single indicator, such as the amplification factor of voltage or current. Input resistance: As an amplifier circuit, there must be a signal source to provide the input

signal. For example, a loudspeaker uses a speaker to convert sound into an electrical signal and provides it to the amplifier circuit. There are also other signals generated after transformation by sensors such as temperature and pressure. A wide variety of electrical signal sources. When the amplifier circuit is connected to the signal source, it needs to obtain current from the signal source. The magnitude of the current indicates the degree of influence of the amplifier circuit on the signal source. Therefore, we define an indicator to measure the influence of the amplifier circuit on the signal source, that is, input resistance. Record as day. Output resistance: After the signal is amplified by the amplifier circuit, it must be sent to a device to play its role. Usually this device is called a load. For example, a speaker is the load

of an amplifier. When we connect another speaker in parallel to the original speaker, the voltage at both ends will drop. This phenomenon shows that there is an equivalent internal resistance from the output end of the amplifier circuit, usually called the output resistance, recorded as R0 . Passband: When only the frequency of the input signal is changed, the amplification factor of the amplifier circuit will change accordingly, and the phase of the output waveform will change accordingly.

The bits will also change, which requires an indicator to reflect the adaptability of the amplifier circuit to signals of different frequencies. Generally speaking, amplifier circuits are only suitable for amplifying signals in a specific frequency range. When the signal frequency is too high or too low, the amplification factor will drop significantly. When the signal frequency increases and the amplification factor drops to 0.7 times the amplification factor (denoted Aum) at the intermediate frequency, this frequency is called the upper limit cutoff frequency, denoted fH; similarly, when the amplification factor drops to 0.7 times Aum The low-frequency signal frequency is called the lower limit cut-off frequency, denoted as fl. We call the frequency band formed between fH and fl the passband, denoted as fBW, that is, fBw=fH - fLo. The wider the passband, the stronger the amplification circuit's ability to adapt to the signal frequency.

Maximum undistorted output voltage: The maximum output amplitude refers to the nonlinear distortion system of the output waveform when the input signal further increases.

The output amplitude will exceed the rated value (such as 10%). The frequency index curve of the amplifier circuit is shown in Figure 2.2.11. Maximum output power

Rom: It is

the maximum power that can be output when the output signal is basically not distorted. It is usually recorded as

Pom.

Efficiency eta: The greater the utilization rate eta of DC power supply energy, the higher the efficiency of the amplifier circuit and the higher the utilization rate of the power supply.

Nonlinear distortion: The distortion caused by the nonlinear characteristics of the amplifier circuit is called nonlinear distortion. For example, the components that make up the amplifier circuit are themselves nonlinear or the operating power supply of the amplifier circuit is limited by a limited voltage.

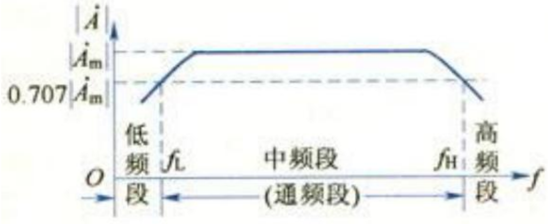


图 2. 2. 11 放大电路的频率指标

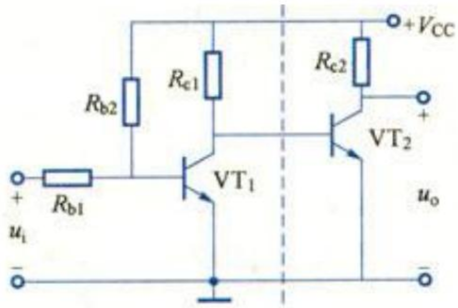


图 2. 2. 12 直接耦合

ÿThe coupling methods between multi-stage amplifier circuits include direct coupling, resistance-capacitance coupling, transformer coupling and photoelectric

coupling. Direct coupling: Direct coupling is to connect the output end of the previous stage to the input end of the lower stage directly or through a constant voltage device, as shown in the figure As shown in 2.2.12, this coupling method not only allows the slowly changing signal to be amplified step by step, but also facilitates circuit integration. However, direct coupling connects the DC between the previous and subsequent stages, causing the DC operating points of each level to influence each other and cannot To remain independent, therefore, the configuration of DC levels between stages must be considered so that each stage has a suitable operating point. In direct-coupled amplifiers, another prominent problem is the so-called zero-point drift, that is, changes in the operating point of the front stage with temperature will be transmitted to the subsequent stages and amplified step by step, causing a large drift voltage to be generated at the output end. Obviously, the more stages and the greater the amplification, the more serious the zero-point drift phenomenon will be. Therefore, in a direct coupling circuit, how to stabilize the working point of the front stage and overcome its drift will become a crucial issue. The outstanding advantage of the direct coupling amplifier circuit is that it has good low-frequency characteristics and can amplify slowly changing signals; and because there are no large-capacity capacitors in the circuit, it is easy to integrate the entire circuit on a silicon chip to form an integrated amplifier circuit. Due to the rapid development of the electronics industry, the performance of integrated amplifier circuits is getting better and better, there are more and more types, and the price is getting cheaper, so the use of direct coupling amplifier circuits is becoming more and more widespread.

Resistor-capacitor coupling: Resistor-capacitor coupling connects the subsequent stage circuit to the front stage through a capacitor, as shown in Figure 2.2.13. Since the capacitor can block DC and pass AC, the DC operating points of each level are independent of each other. When solving and actually debugging the static operating point, it can be processed as a single stage, which brings great convenience to the design, debugging and analysis. It is convenient, and as long as the coupling capacitor is selected large enough, the lower frequency signal can be added from the front stage to the subsequent stage with almost no attenuation, achieving step-by-step amplification. Therefore, the resistance-capacitance coupling method is very effective in discrete component circuits. Wide range of applications. The resistance-capacitance coupling amplification circuit has poor low-frequency characteristics and cannot amplify slowly changing signals. This is because the capacitor presents a large capacitive reactance to such signals, and part or even all of the signal is attenuated on the coupling capacitor and does not flow to the downstream stage at all. In addition, it is difficult or even impossible to manufacture large-capacity capacitors in integrated circuits, so this coupling method is not convenient for integration.

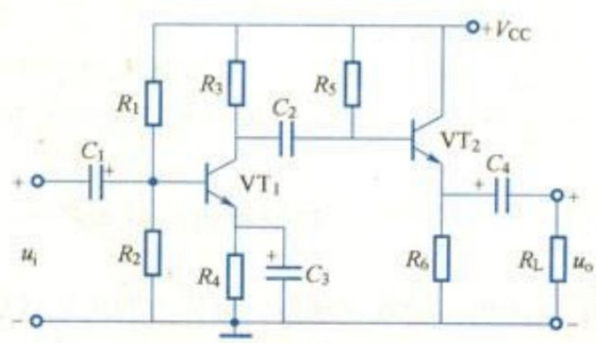


图 2. 2. 13 阻容耦合

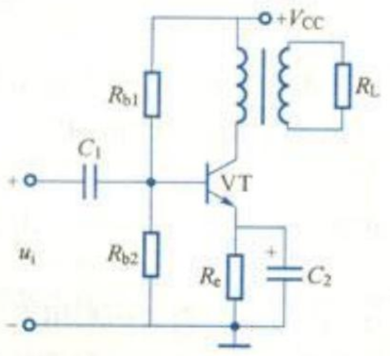


图 2. 2. 14 变压器耦合

Transformer coupling: Transformer coupling is to connect the output end of the front stage of the amplifier circuit to the input end or load of the subsequent stage through a transformer. on the resistor, as shown in Figure 2.2.14. Since the front and rear stages of the transformer coupling circuit are coupled by magnetic circuits, like the resistance-capacitance coupling circuit, the static operating points of its amplifier circuits at all levels are independent of each other, which is convenient for analysis, design and debugging. However, its low-frequency characteristics are poor and cannot be It amplifies slowly changing signals and is very bulky and cannot be integrated. Compared with the first two coupling methods, its biggest feature is that it can realize impedance transformation, so it is widely used in discrete component power amplifier circuits.

Photoelectric coupling: The coupling elements of the front and rear stages of photoelectric coupling are photoelectric coupling devices, as shown in Figure 2.2.15. The output signal of the front stage is converted into a light signal through a light-emitting diode. The light signal is illuminated on the phototransistor, and the phototransistor restores it back to an electrical signal and sends it to the input end of the subsequent stage. Photoelectric coupling can transmit both AC signals and DC signals; it can achieve front and rear isolation and is easy to integrate, so it is widely used. ÿ The amplification factor of the multi-stage amplification circuit: The total amplification

factor of the multi-stage amplification circuit is equal to the product of the amplification factors of each level amplification circuit. ÿThe types of low-frequency power amplifier circuits include

Class A power amplifier circuits, Class B power amplifier circuits and Class A and B power amplifier circuits.

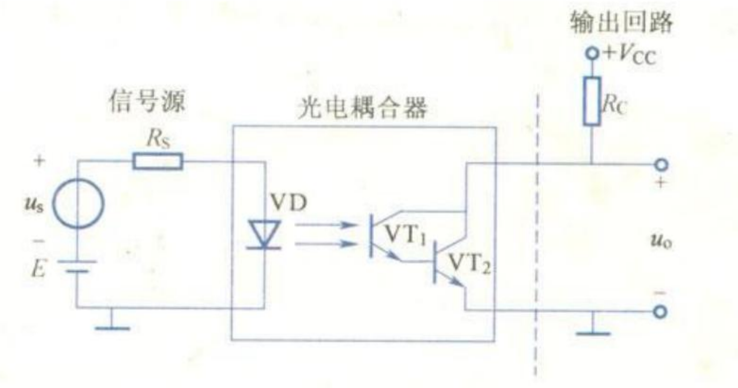


图 2. 2. 15　光电耦合

3. Detection circuit knowledge ÿ

Detection. The demodulation of amplitude modulated signals is to restore the original modulated signals from the modulated signals. It is the reverse process of modulation and is called amplitude detection, or detection for short. From the spectrum relationship shown in Figure 2.2.16, amplitude modulation moves the spectrum of the modulated signal to the vicinity of the high-frequency carrier, while detection moves the modulated sideband signal from the vicinity of the high-frequency carrier to the original without distortion. position, so the detection circuit is also a spectrum shifting circuit.

ÿClassification of detection. Detection can be divided into two categories: envelope detection and synchronous detection. Envelope detection refers to a detection method in which the output voltage of the detector directly reflects the changing pattern of the envelope of high-frequency amplitude modulated waves; synchronous detection means that the two high-frequency signals acting on the detector not only have the same frequency, but also have basically the same phase. That is, these two high-frequency signals are completely synchronized. 4ÿ Voltage

comparator knowledge ÿ Simply put, a voltage comparator compares two analog voltages (there are also two digital voltages that compare), determines which one of them has a higher voltage, and then outputs the corresponding level at the output end. Figure 2.2.17 is the voltage comparator circuit and characteristic curve.

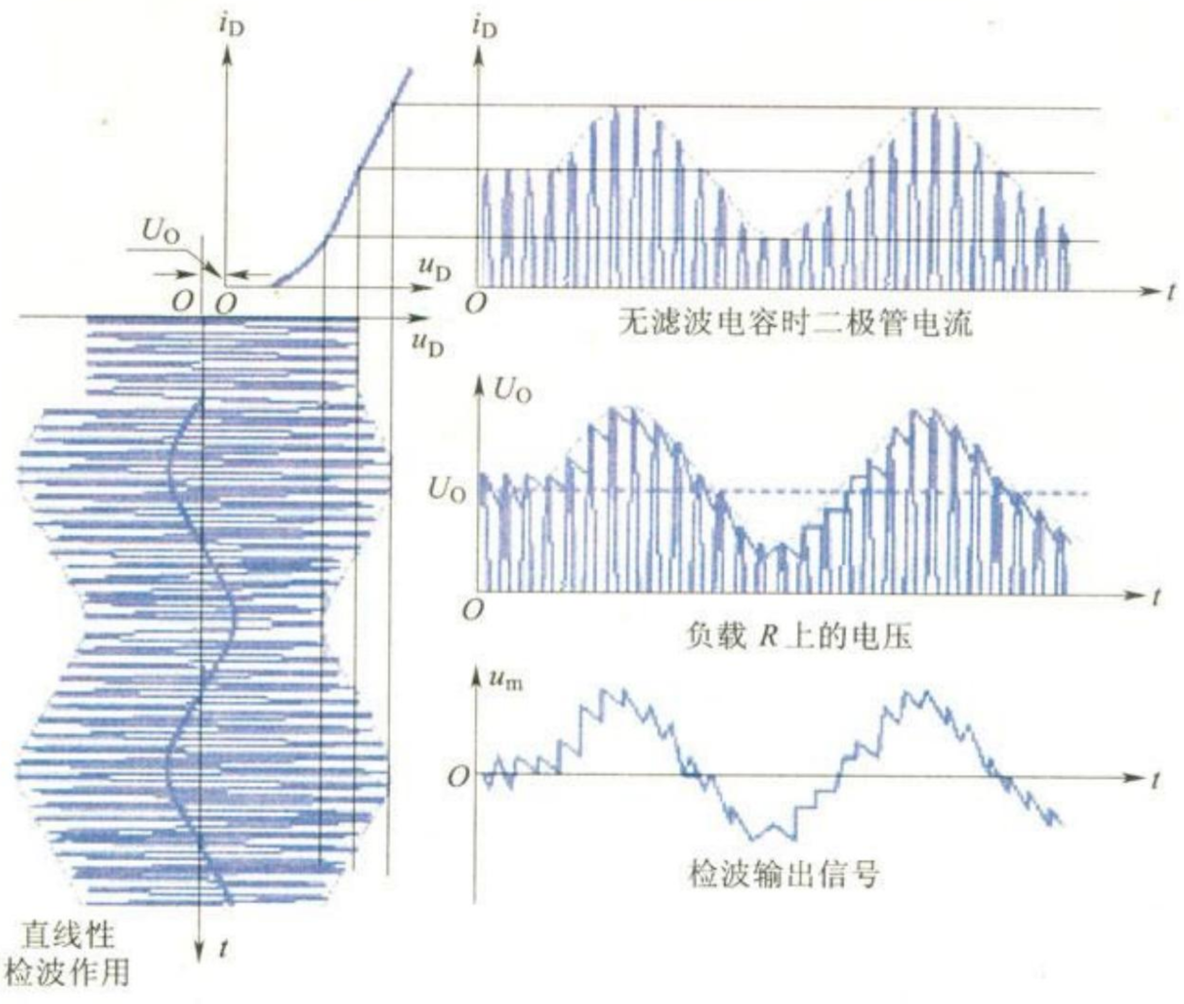


图 2. 2. 16 检波频谱关系图

ÿVoltage comparators can be used in alarm circuits, automatic control circuits, measurement technology, and can also be used in V/F conversion circuits, A/D conversion circuit, high-speed sampling circuit, power supply voltage monitoring circuit, oscillator and voltage-controlled oscillator circuit, zero-crossing detection circuit Lu et al.

ÿTypes of voltage comparators include: zero-crossing comparator, arbitrary level comparator, inverting hysteresis comparator, non-phase hysteresis ratio comparator and double-limited voltage comparator.

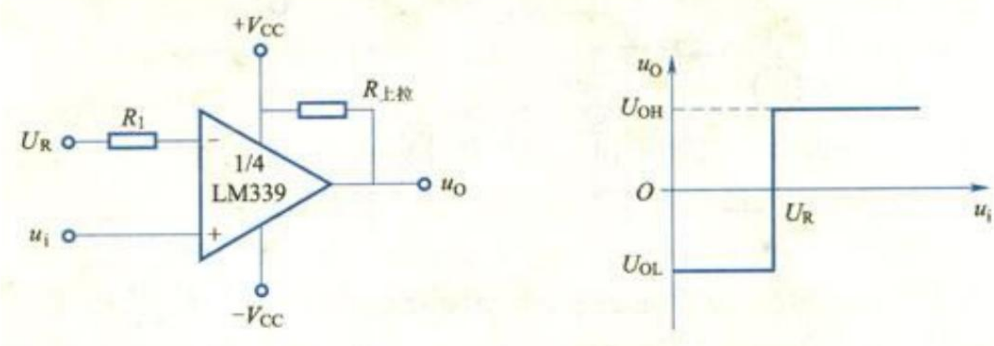


图 2. 2. 17 电压比较器及特性